arXiv:astro-ph/0105378 22 May 2001

A GIANT AIR SHOWER ARRAY IN NORD RHEIN WESTFALEN

HINRICH MEYER
Fachbereich Physik, Bergische Universität Wuppertal, P.O. Box, D-42097 Wuppertal, Germany

A proposal is presented to construct a very large air shower array in the densely populated central area of Nord-Rhein-Westfalen (NRW). The aim would be to reach a size of approximately 4000 km^2 to study the highest energy end of the all particle cosmic ray spectrum, as it is accessible in the northern hemisphere.

1 Basic Considerations

The energy spectrum of cosmic rays appears to extend unattenuated beyond $5 \cdot 10^{19}$ eV although photoproduction of pions by collisions of the primary protons with the universal $2.7°$ K microwave background should have cut off the cosmic ray energy spectrum[1]. The assumption that the highest energy particles of cosmic rays are protons is a most natural one and is also in accord with the observed features of the giant air showers. If the astrophysical sources of the cosmic rays are on average far enough away, that is 100 Mpc or more and with protons as the primary particles, the cut off of the spectrum is unavoidable. Then we have the classical controversy about distances of sources, near of far, that played a fundamental role in many astrophysical phenomena, like recently for the gamma ray bursts (GRB). Only observations decide.

Two questions need to find a definite answer experimentally

- do the highest energy particles come from preferred locations on the sky (sources)
- what are the highest energies of cosmic rays (end of the spectrum)

and closely related to those two questions, what is the nature of the particles: are they protons, nuclei, photons, neutrinos or rather exotic objects.

The particle flux near the end of the spectrum is low, about one event per 100 km^2 and year. To collect sufficient statistics needed for a successful experiment, a giant detector is required with more than 1000 km^2 area to improve the acceptance by at least an order of magnitude over AGASA[2].

I have considered a highly populated and technically advanced area as a viable solution to the requirements for a successful air shower array. This follows the basic idea of AGASA but here for an area that is famous for its high level of industrialisation. A look at the Rhein-Ruhr area between Duisburg, Dortmund, Köln and Bonn reveals that one will find a power outlet almost every km. Furthermore, with Düsseldorf, Essen, Bochum, Wuppertal and a little farther out, Münster, Siegen and Aachen (in addition to the 4 cities above) one has an unparalleled density of universities. The triangle with Bonn, Duisburg and Dortmund at the corners covers an area of 4300 km^2 and a triangle with Aachen, Siegen and Münster, an area twice as large can be achieved for the deployment of a giant air shower array.

2 Structure of the Array

Considering a threshold of 10^{19} GeV one would choose, based on previous experiments, about 1.5 km distance between stations. To efficiently cut accidentals to a negligible level at a given station, 3 detectors with spacing of 5 - 10 m are foreseen, operated at a 2 out of 3 coincidence. The exact conditions can easily be chosen such that a basic rate per station of a few Hz is obtained.

In addition to the amplitude vs. time from the detectors, an absolute time derived from the global positioning system (GPS) is recorded for each event. From a local buffer the information is transmitted via internet to a local base preferably at the nearest university and the large showers are reconstructed offline. In this context it may be of considerable interest for the project that power companies in NRW develop internet connections via the power grid, the use of which then may considerably simplify the communication structure in the array.

The basic detector should be a 2 m^2 scintillator with wavelength shifter readout using photodiodes. The detector should be covered by a strong and tight box that can easily be located in any reasonable environment.

Of particular concern is the acceptance of particles at larger zenith angles because of the possibility to catch highest energy neutrinos. A recent reanalysis of Haverah Park data has shown the large potential of events in the angular range $> 60°$, in particular for primary particle identification, in fact a rather strong upper limit on photons as the highest energy particles could be derived[3].

The geometry of the scintillators should therefore allow for significant acceptance at large zenith angles, which is certainly possible. The energy threshold of a triple of the detectors at a given location will be around 100 TeV and from the three counters a crude angular pointing for each shower of about $(5-8)°$ can be derived. A large array then allows to search for long range coincidences at scales of 10th of km which has been attempted previously with little success, but also with insufficient instrumentation. A large array then with several thousand stations would certainly be of considerable value to investigate this problem.

As a further strategy point I would prefer to go for the largest possible area, even at the expense of the density of stations at the early phase of the experiment. This will shift up the energy threshold, however to detect events far above the GZK cutoff would be of great importance and is one of the main goals of the experiment.

In line with the discussion above one should start with part of the array in a rather dense environment that means at the center of one of the larger cities. As an example I have chosen (of course) Wuppertal, which is located approximately in the center of the 4300 km^2 triangle. Within the city limit an area of about 240 km^2 is enclosed. Dividing the area up into 2 km $\times$

2 km squares 60 stations need to be deployed. This results in an array that is 2.4 times larger than AGASA which would provide a very reasonable start. The cities of Duisburg, Dortmund and Bonn would mark the corners of the triangle and should be instrumented in a similar way.

3 Public Outreach

A further important consideration concerns the type of locations for the deployment of the stations. It appears that e.g. for the case of Wuppertal a considerable fraction of the 2 km $\times$ 2 km squares contain one or more schools. It then seems prudent to consider them as the preferred location for the stations. The schools are for the large majority on public ground. They have power and can be considered a well protected place. In addition, both teachers and pupils should develop interest to participate in the experiment as such. No school would be preferred, each of the stations is of exactly the same importance in the array. This way the schools will be an integral part of an experiment in basic science, connected by a very large network in the central part of NRW.

Actually, the network may as well form the basis for other research activities that require a 100% ontime in a very well controlled manner. I think one should not underestimate the possible impact of such an enterprise for popularising basic science in schools and for building and maintaining connections beween schools and universities.

4 Conclusion

The construction of a giant air shower array in the central part of NRW is proposed. The area of 4300 km^2 foreseen makes it comparable in size to the AUGER projects. Unique of this proposal is, however, the connection to public schools that provides an elegant opportunity of popularising basic science.

Acknowledgments

I would like to thank the organisers of this meeting for providing a very stimulating atmosphere and for a generous support.

References

1. K. Greisen, Phys. Rev. Lett. 16 748, 1966,
   G.T. Zatsepin, V.A. Kuzmin, JETP Lett. 4, 78, 1966
2. M. Teshima, these proceedings
3. M. Ave Pernas, these proceedings